



**Full Blown Crude Assay Analysis
for
Cairn India Limited
Ravva Oil
Certificate No: LB1465C**

Final Report

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Summary of Sample Appearance and Analytical Laboratory Procedures

Sample Details

A crude oil sample from Cairn India Limited was received in our Labuan laboratory on 29th-Dec-16 for Full Blown Crude Assay. The detailed description of sample received is listed below.

Crude Name : **Ravva Oil**

Sampling Date : -

Sampling Time : **NA**

Sampled by : **NA**

Summary Of Sample Appearance

We found the sample is solid at ambient temperature (25°C). The sample present 2 liter of free water content and 12% by volume of emulsion. The emulsion, then has gone for a centrifuge process to ensure to get the dry oil as much as possible before conducting the Distillation by ASTM D2892.

A series of analyses was performed on the above sample to fulfill the analytical matrix indicated in Appendix 1. A brief description of the testing methods used are indicated below.

True Boiling Point Distillation (ASTM D2892)

This test provides a means to quantify the yields of fractions from various boiling ranges and is primarily used to quantify the commercial value of petroleum crudes. This method involves the distillation of petroleum crudes or like materials to end point of 400°C AET (Atmospheric Equivalent Temperature) using a fractionating column with efficiency of 14 through 18 theoretical plates. A reflux ratio of 5:1 is used throughout this process.

Fractions at cut points are recovered – typically this is requested by the client. Mass and density of each fraction are then measured. Distillation yields in mass % and volume % are calculated and are then illustrated in tabular and chart form. In cases where the end point of the distillation exceeds 400°C AET, this test is continued using the Potstill Distillation technique.

Potstill Distillation (ASTM D5236)

This test provides an estimate of yields on heavy hydrocarbon mixtures up to an end point of 565°C AET. This method utilizes total takeoff conditions and is used in conjunction with TBP Distillation (ASTM D2892) to generate a distillation curve beyond 400°C AET.

Fractions at client desired cut points are collected and mass and density for each fraction measured. Distillation yields in mass % and volume % are calculated and illustrated in tabular and chart form. The fractions collected by both these distillation techniques are used to perform various quantitative analyses to verify the quality of whole crude oil.

Extended Compositional Analysis of Liquid Hydrocarbons

This method covers the quantitative determination of petroleum crudes through C36 plus. This technique utilizes a gas chromatograph equipped with a temperature programmed on-column injector, a temperature programmed column oven, a wide bore column, an auto-sampler capable of injecting identical volumes and a flame ionization detector (FID). The analytical process involves the calculation of concentrations of individual hydrocarbons by means of comparing peak areas of a fully eluting external standard with sample crude oil.

Simulated Distillation (ASTM D7169)

This test involves the determination of boiling point distribution through 720°C of petroleum crudes by high temperature gas chromatography (HTGC). The end point of 720°C corresponds to nC100. This method utilizes a high temperature gas chromatograph equipped with on-column injector, a temperature programmed column oven, a short wide bore column capable of withstanding temperatures of 435°C, an auto-sampler capable of injecting identical volumes and a flame ionization detector (FID). The test process involves the use of an external reference standard oil to determine the boiling point distribution of petroleum crudes.

Fraction Analyses

Fractions collected during the distillation processes are then used for further analyses. A series of analyses as per the analytical test matrix depicted in Appendix 1 was performed. These tests were performed to industry recognized standards such as American Society for Testing and Materials (ASTM), Institute of Petroleum (IP) and Universal Oil Products (UOP). The test methods used to characterize the crude oil and fractions are listed in Appendix 2.

Table 1 : Whole Crude Oil Properties

No	Analytical Test	Method	Unit	Result	Mass Balance
1	Density @ 15 °C	ASTM D5002	g/cm3	0.8464	0.8475
2	Specific Gravity @ 60/60 F	Calculated	-	0.8468	
3	API Gravity @60°F	Calculated	-	35.59	35.37
4	Density @ 15.6 °C (60 °F)	ASTM D5002	g/cm3	0.8460	
5	Density @ 15 °C	ASTM D1298	g/cm3	0.8415	
6	API Gravity @60°F	ASTM D1250-80	-	36.57	
7	Composition of Whole Crude	GC	wt %	See Page 6	
8	Composition (LPG)	GC	wt %	See Page 10	-
9	Ash Content	ASTM D482	wt %	0.029	-
10	Basic Nitrogen	UOP - 269	wt %	0.0195	-
11	Asphaltenes Stability	ASTM D7112	-	See Page 4	-
12	Carbon Residue	ASTM D4530	% m/m	0.89	-
13	Cold Filter Plugging Point	IP - 309	°C	##	-
14	Conradson Carbon Residue	ASTM D189	wt %	0.91	-
15	Flash Point (PMCC)	ASTM D 93	°C	< -20.0	
16	Hydrogen Sulphide Content	UOP - 163	ppm wt	ND	
17	Kinematic Viscosity @ 40°C	ASTM D445	cSt	4.189	
18	Kinematic Viscosity @ 50°C	ASTM D445	cSt	3.450	
19	Kinematic Viscosity @ 100°C	ASTM D445	cSt	1.726	
20	Viscosity Gravity Constant @ 100°C	ASTM D2501	-	0.8262	
21	KUOP - Factor	UOP - 375	-	12.0	
22	Mercaptan Sulphur	ASTM D3227	ppm wt	10	
23	Mercury	UOP 938	ppb wt	< 5.0	
24	Metal - Copper (Cu)	AAS	ppm wt	<1	
	- Iron (Fe)	AAS	ppm wt	6	
	- Nickel (Ni)	AAS	ppm wt	3	
	- Sodium (Na)	AAS	ppm wt	3	
	- Vanadium (V)	AAS	ppm wt	<1	
25	Molecular Weight	Cryoscope	g/mole	201	
26	Pour Point	ASTM D97/5853	°C	+30	
27	Reid Vapour Pressure	ASTM D323	psi	##	
28	Salt Content	ASTM D3230	lb/1000bbbls	8.8	
29	SARA - Saturate	ASTM D2007	wt %	84.17	
	-Aromatic	ASTM D2007	wt %	10.20	
	-Resin	ASTM D2007	wt %	5.21	
	-Asphaltenes	ASTM D2007	wt %	0.42	
30	Sediment by Extraction	ASTM D473	wt %	0.04	
31	Sulphur Content	ASTM D129	wt %	0.03	
32	Total Acid Number	ASTM D664	mgKOH/g	0.13	
33	Total Nitrogen	ASTM D3228	wt %	0.047	
34	Total Nitrogen	ASTM D4629	ppm (wt)	465	
35	Water Content	ASTM D95	vol %	0.65	
36	WAT	DSC	°C	31.7	
37	WDT	DSC	°C	41.2	
38	Wax Content	UOP 46	wt %	14.6	

Remarks :

1) SG @60/60°F and the API is calculated using Table Measurement as mentioned in ASTM D1250.

2) ND : Not Detected

3) ## : Cannot perform the test due to the sample is solid at the test temperature.

4) Data for item number 5 is used Hydrometer technique and result for item number 6 is calculated using data from item number 5.

Table 1 (Continue) Stability Test : Whole Crude Oil Properties

No	Analytical Test	Method	Unit	Result	Remarks
1	Stability Test		-		
	Density			0.8464	Used for the calculation of S_{BN} & I_N
	P-Value		-	NA	NA
	Xylene Equivalent		-	NA	NA
	Solubility Blending Number (S_{BN})	ASTM D7112	-	33.9	The Ravva crude has very low Solubility Blending Number (S_{BN}). There is a high risk of incompatibility if Ravva crude is mixed with other crude oil source.
	Insolubility Number (I_N)		-	NA	NA

Summary of test method ASTM D7112 using Porla Analyzer as below.

Stability and compatibility parameters are determined by titration and optical detection of precipitate Asphaltenes. A stock Solution is prepared and three different mixtures of the sample oil plus Xylene are titrated with n-Heptane to cause precipitation of Asphaltenes. The titrated mixture is continuously circulated through an optical detector which detects precipitated Asphaltenes by back-scattering of visible light. The amount of Oil, Xylene and n-Heptane are used to calculate Stability parameters: Solvent Equivalent, P-value and FR5/1. If the density of a crude oil sample is known, then the compatibility parameters (S_{BN} and I_N) of the crude oil may also be calculated.

The principal of work for Porla Analyzer is based on titrating a mixture of oil and aromatic solvent with paraffinic solvent to cause flocculation of Asphaltenes and flocculated Asphaltenes are detected by optical detection.

Porla Analyzer has two methods:

For samples containing Asphaltenes, a complete set of results including P-value, Xylene Equivalent, Solubility Blending Number (S_{BN}), Insolubility Number (I_N) are reported.

For oil with no Asphaltenes, only the determination of Solubility Blending Number (S_{BN}) is possible.

We have tried several attempts to analyze Ravva Crude Oil using normal method, however no flocculation of Asphaltenes was detected by optical detector when the crude sample is titrated using n-Heptane. Therefore, laboratory has proceeded to analyze the crude using Asphaltenes free method which would only provide Solubility Blending Number (S_{BN}) result.

Table 2 : Summary of Product Cut Points and Yields

Cut Point (°C)	Product	Yield On Crude (Mass %)		Yield On Crude (Volume %)	
		Cut	Cumulative	Cut	Cumulative
LPG	LPG	0.72	0.72	1.13	1.13
C5 - 40	Naphtha	0.68	1.40	0.91	2.04
40 - 70	Naphtha	3.00	4.40	3.54	5.58
70 - 100	Naphtha	2.79	7.19	3.15	8.73
100 - 120	Naphtha	3.55	10.74	3.97	12.70
120 - 140	Naphtha	3.35	14.09	3.68	16.38
140 - 160	Naphtha	3.35	17.44	3.59	19.97
160 - 190	Naphtha	4.99	22.43	5.28	25.25
190 - 210	Kerosene	3.84	26.27	3.98	29.23
210 - 230	Kerosene	3.98	30.25	4.07	33.30
230 - 240	Kerosene	2.20	32.45	2.22	35.52
240 - 260	Kerosene	5.89	38.34	5.86	41.38
260 - 280	Light Gas Oil	5.79	44.13	5.71	47.09
280 - 300	Light Gas Oil	6.45	50.58	6.41	53.50
300 - 330	Light Gas Oil	6.11	56.69	6.06	59.56
330 - 360	Heavy Gas Oil	5.50	62.19	5.40	64.96
360 - 380	Heavy Gas Oil	3.89	66.08	3.82	68.78
380 - 400	Heavy Gas Oil	4.45	70.53	4.36	73.14
400 - 420	Heavy Gas Oil	4.04	74.57	3.87	77.01
420 - 450	Vacuum Gas Oil	6.80	81.37	6.41	83.42
450 - 470	Vacuum Gas Oil	4.59	85.96	4.29	87.71
470 - 490	Vacuum Gas Oil	3.66	89.62	3.38	91.09
490 - 510	Vacuum Gas Oil	2.49	92.11	2.25	93.34
510 - 540	Vacuum Gas Oil	1.17	93.28	1.05	94.39
540 +	Residue	6.72	100.00	5.61	100.00

Figure 1 : Summary of Product Cuts - Bar Chart (Yield % on Crude Oil)

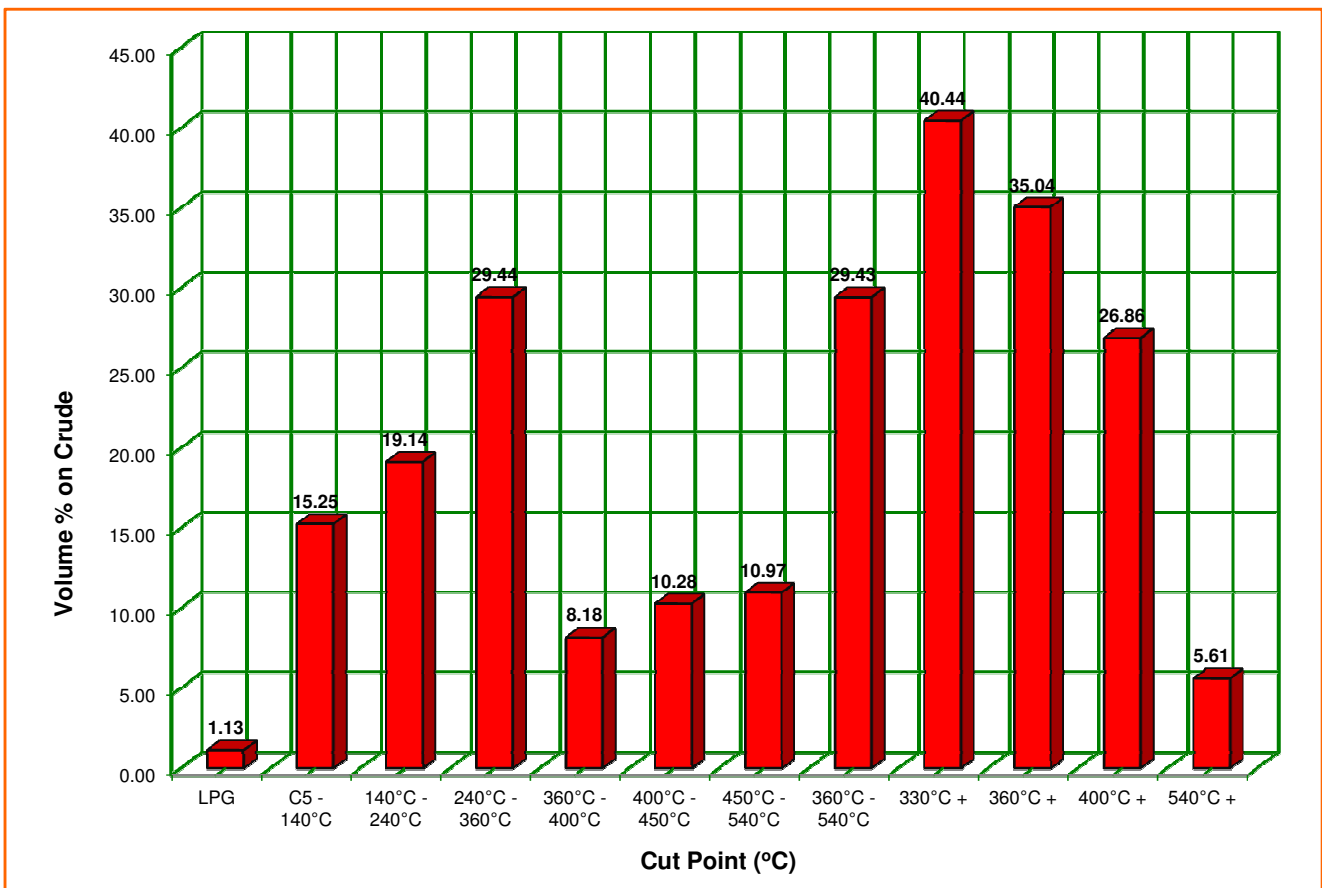
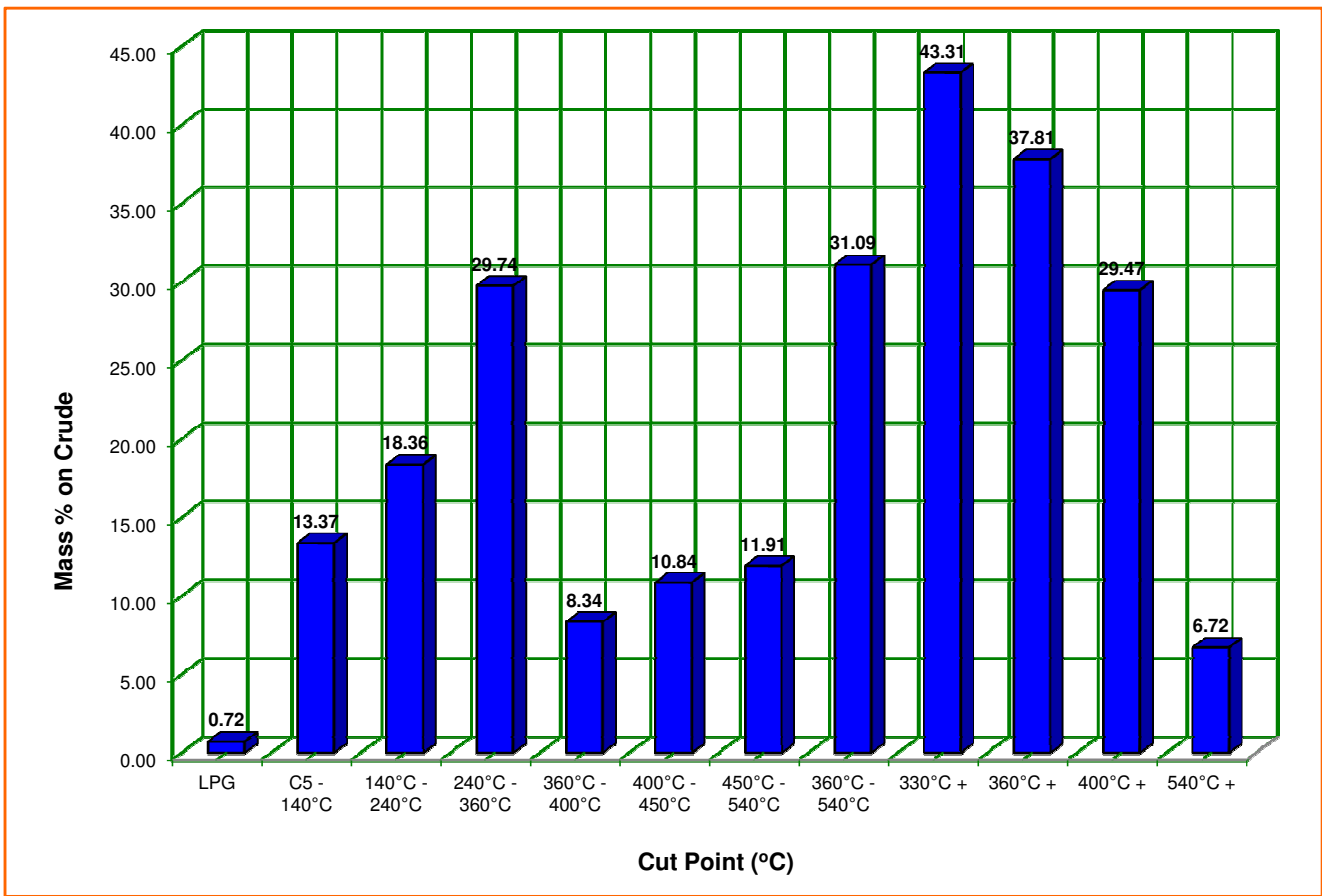


Table 3 : Whole Crude Oil Composition Analysis
Compositional Analysis Data by Gas Chromatography Technique

Component	Mass %	Mol %
Methane	0.000	0.000
Ethane	0.001	0.006
Propane	0.052	0.245
iso-Butane	0.083	0.297
n-Butane	0.262	0.935
iso-Pentane	0.301	0.866
n-Pentane	0.401	1.152
Hexanes	1.038	2.629
Heptanes	3.622	8.522
Octanes	5.550	11.291
Nonanes	4.287	7.697
Decanes	4.192	6.482
Undecanes	3.673	5.182
Dodecanes	3.681	4.741
Tridecanes	4.016	4.758
Tetradecanes	4.440	4.846
Pentadecanes	5.632	5.670
Hexadecanes	4.025	3.760
Heptadecanes	3.314	2.900
Octadecanes	3.973	3.283
Nonadecanes	2.811	2.216
Eicosanes	2.506	1.890
Henicosanes	2.400	1.711
Docosanes	2.313	1.572
Tricosanes	2.254	1.470
Tetracosanes	2.187	1.370
Pentacosanes	2.198	1.321
Hexacosanes	2.120	1.224
Heptacosanes	2.133	1.183
Octacosanes	2.133	1.140
Nonacosanes	2.189	1.129
Triacosanes	2.163	1.078
Hentriacontanes	2.026	0.977
Dotriacontanes	1.791	0.836
Tritriacontanes	1.608	0.728
Tetratriacontanes	1.133	0.498
Pentatriacontanes	0.938	0.400
Hexatriacontanes plus	12.554	3.995
TOTAL	100.000	100.000

Figure 2 : Whole Crude Chromatogram by Gas Chromatography

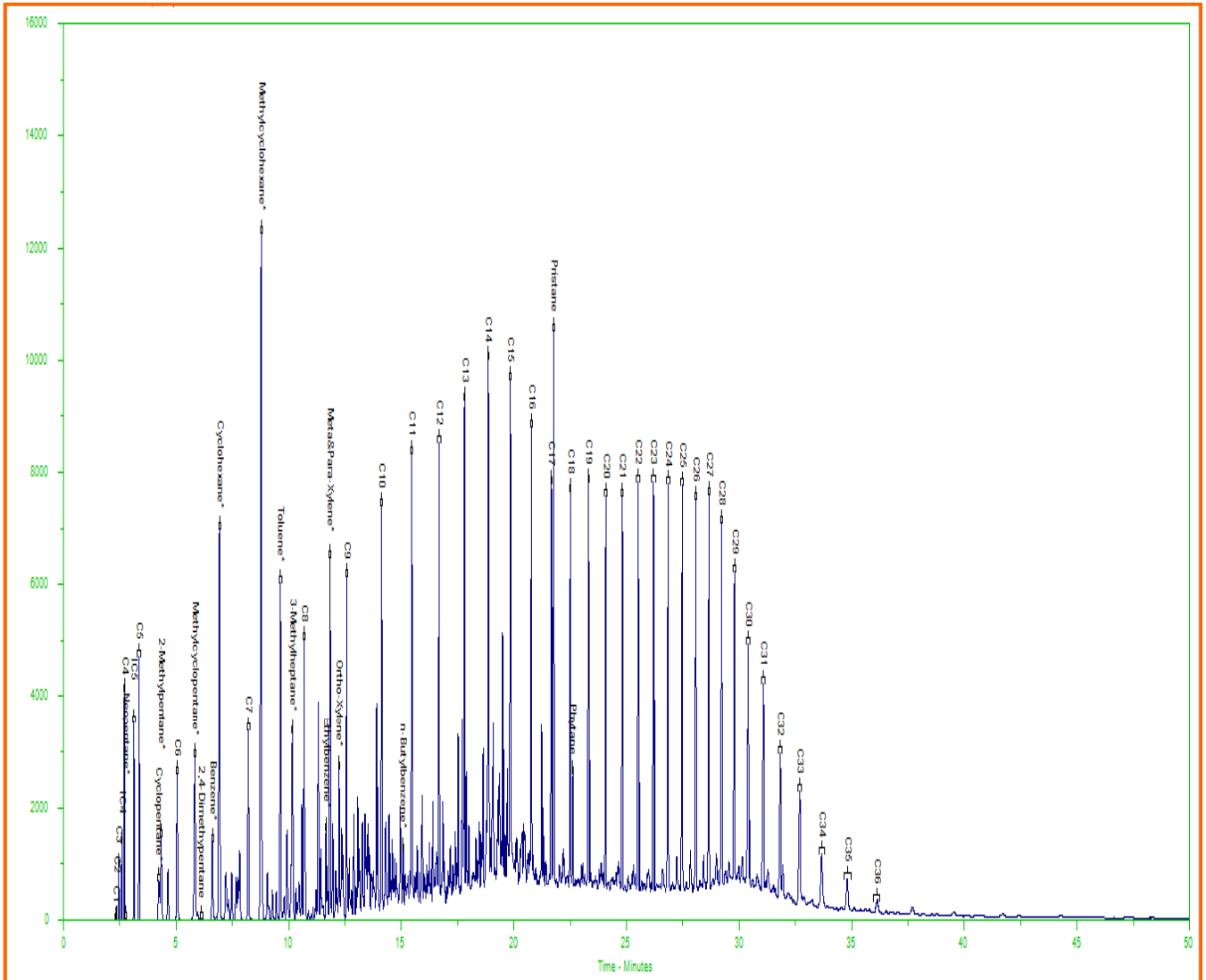


Table 4 : Boiling Range Distribution by SIMDIS (ASTM D7169)

No	Boiling Point (°C)	Cumulative Yield (Mass %)	No	Boiling Point (°C)	Cumulative Yield (Mass %)
IBP	68.3	0.5	51	301.4	51
1	71.9	1	52	302.4	52
2	78.0	2	53	306.0	53
3	86.0	3	54	312.8	54
4	97.1	4	55	316.3	55
5	98.1	5	56	319.5	56
6	101.5	6	57	326.6	57
7	108.7	7	58	330.4	58
8	115.0	8	59	334.7	59
9	125.8	9	60	342.1	60
10	130.0	10	61	344.4	61
11	136.4	11	62	350.8	62
12	141.0	12	63	356.3	63
13	146.1	13	64	359.3	64
14	150.9	14	65	366.9	65
15	157.5	15	66	369.2	66
16	162.1	16	67	375.1	67
17	166.3	17	68	379.9	68
18	173.5	18	69	382.7	69
19	176.5	19	70	389.8	70
20	181.2	20	71	391.5	71
21	188.9	21	72	397.9	72
22	194.6	22	73	401.7	73
23	196.7	23	74	405.7	74
24	201.8	24	75	411.3	75
25	208.5	25	76	413.1	76
26	214.8	26	77	418.6	77
27	216.6	27	78	421.7	78
28	221.7	28	79	424.5	79
29	225.4	29	80	429.1	80
30	230.1	30	81	431.3	81
31	234.6	31	82	435.2	82
32	236.0	32	83	439.3	83
33	240.6	33	84	441.3	84
34	244.6	34	85	446.1	85
35	247.3	35	86	449.3	86
36	249.9	36	87	454.9	87
37	253.3	37	88	458.5	88
38	254.4	38	89	465.4	89
39	257.5	39	90	470.3	90
40	261.8	40	91	475.2	91
41	264.9	41	92	482.0	92
42	268.6	42	93	490.6	93
43	271.0	43	94	500.6	94
44	272.7	44	95	511.8	95
45	278.3	45	96	525.1	96
46	283.9	46	97	539.7	97
47	287.2	47	98	557.1	98
48	290.4	48	99	576.8	99
49	294.6	49	100	587.5	99.5
50	300.0	50			

Table 5 : True Boiling Point Data (ASTM D2892 & ASTM D5236)

Cut No.	Cut Point AET (°C)	Method Used	Yield % On Crude				Density at 15 °C (g/cm ³)
			Mass %		Volume %		
			Cut	Cumulative	Cut	Cumulative	
1	LPG	ASTM D2892	0.72	0.72	1.13	1.13	0.5405
2	C5 - 40	ASTM D2892	0.68	1.40	0.91	2.04	0.6418
3	40 - 70	ASTM D2892	3.00	4.40	3.54	5.58	0.7215
4	70 - 100	ASTM D2892	2.79	7.19	3.15	8.73	0.7570
5	100 - 120	ASTM D2892	3.55	10.74	3.97	12.70	0.7657
6	120 - 140	ASTM D2892	3.35	14.09	3.68	16.38	0.7794
7	140 - 160	ASTM D2892	3.35	17.44	3.59	19.97	0.7887
8	160 - 190	ASTM D2892	4.99	22.43	5.28	25.25	0.7993
9	190 - 210	ASTM D2892	3.84	26.27	3.98	29.23	0.8170
10	210 - 230	ASTM D2892	3.98	30.25	4.07	33.30	0.8268
11	230 - 240	ASTM D2892	2.20	32.45	2.22	35.52	0.8370
12	240 - 260	ASTM D2892	5.89	38.34	5.86	41.38	0.8508
13	260 - 280	ASTM D2892	5.79	44.13	5.71	47.09	0.8581
14	280 - 300	ASTM D2892	6.45	50.58	6.41	53.50	0.8528
15	300 - 330	ASTM D2892	6.11	56.69	6.06	59.56	0.8533
16	330 - 360	ASTM D2892	5.50	62.19	5.40	64.96	0.8618
17	360 - 380	ASTM D2892	3.89	66.08	3.82	68.78	0.8621
18	380 - 400	ASTM D2892	4.45	70.53	4.36	73.14	0.8633
19	400 - 420	ASTM D5236	4.04	74.57	3.87	77.01	0.8827
20	420 - 450	ASTM D5236	6.80	81.37	6.41	83.42	0.8989
21	450 - 470	ASTM D5236	4.59	85.96	4.29	87.71	0.9055
22	470 - 490	ASTM D5236	3.66	89.62	3.38	91.09	0.9171
23	490 - 510	ASTM D5236	2.49	92.11	2.25	93.34	0.9350
24	510 - 540	ASTM D5236	1.17	93.28	1.05	94.39	0.9448
25	540 +	ASTM D5236	6.72	100.00	5.61	100.00	1.0144
26	330 +	ASTM D2892	43.31	100.00	40.44	100.00	0.9059
27	360 +	ASTM D2892	37.81	100.00	35.04	100.00	0.9127
28	400 +	ASTM D2892	29.47	100.00	26.86	100.00	0.9271

Table 6 : Liquefied Petroleum Gas (LPG) Cut Composition

No.	Composition	Method	Results			
			(On Fraction)		(On Crude)	
			Mass %	Volume %	Mass %	Volume %
1	Carbon Dioxide	GPA 2261	1.26	0.83	0.01	0.01
2	Methane		0.44	0.80	0.00	0.01
3	Ethane		1.45	2.19	0.01	0.02
4	Propane		42.12	44.86	0.30	0.51
5	i-Butane		27.72	26.62	0.20	0.30
6	n-Butane		23.42	21.67	0.17	0.24
7	neo-pentane		0.00	0.00	0.00	0.00
8	i-Pentane		1.67	1.45	0.01	0.02
9	n-Pentane		0.84	0.72	0.01	0.01
10	Hexanes Plus		1.07	0.87	0.01	0.01
Totals			100.00	100.00	0.72	1.13

Notes:

LPG Mass % Yield : 0.72
LPG Vol % Yield : 1.13

Table 7 : Light / Medium Naphtha Cuts Analyses

Analytical Tests	Method	Unit	Results		
			C5 - 140 °C	140 °C - 240 °C	240 °C - 360 °C
Yield on Crude	ASTM D2892	mass %	13.37	18.36	29.74
Yield on Crude	ASTM D2892	vol %	15.25	19.14	29.44
Mid Volume %	ASTM D2892	vol %	8.76	25.95	50.24
Density @ 15°C	ASTM D 4052	g/cm ³	0.7510	0.8114	0.8551
API Gravity @ 60°F	Calculated	-	56.83	42.80	33.89
Specific Gravity @ 60/60°F	Calculated	-	0.7513	0.8118	0.8555
Density @ 15.6 °C (60 °F)	ASTM D 4052	g/cm ³	0.7505	0.8110	0.8547
Aniline Point	ASTM D 611	°C		51.60	71.40
Antiknock Index (AKI)	ASTM D4814	-	68.0		
Basic Nitrogen	UOP - 269	wt %			0.0041
Calculated Cetane Index	ASTM D4737	-		37.6	53.0
Carbon Content	ASTM D5291	wt %		86.70	
Hydrogen Content	ASTM D5291	wt %		15.10	
Cloud Point	ASTM D2500	°C			5
Colour Saybolt	ASTM D 156	-		+30	
Color - ASTM	ASTM D1500	-			L1.0
Copper Corrosion @ 100°C, 2 hrs	ASTM D130			1a	
Copper Corrosion @ 50°C, 3 hrs	ASTM D130				1a
Cetane Number	ASTM D613	-			52.10
FIA - Aromatic	ASTM D 1319	vol %	12.4	20.9	
- Olefin	ASTM D 1319	vol %	0.0	0.0	
- Saturate	ASTM D 1319	vol %	87.6	79.1	
Freezing Point	ASTM D 2386	°C	<-70.0	-53.5	
Flash Point (Abel)	IP 170	°C		43.0	
Flash Point (PMCC)	ASTM D 93	°C			114.0
Kinematic Viscosity @ - 20 °C	ASTM D 445	cSt		3.024	
Kinematic Viscosity @ 20 °C	ASTM D 445	cSt		1.490	
Kinematic Viscosity @ 40 °C	ASTM D445	cSt		1.152	3.905
Kinematic Viscosity @ 50 °C	ASTM D445	cSt		1.032	3.126
Kinematic Viscosity @ 70 °C	ASTM D 445	cSt		0.839	2.187
Viscosity Gravity Constant @ 40 °C	ASTM D2501	-			##
Mercaptan Sulphur	ASTM D3227	ppm wt	0.25	0.38	
Motor Octane Number	ASTM D2700	-	67.0		
Naphthalene Content	ASTM D 1840	vol %		2.3	
Pour Point	ASTM D97/5853	°C			0
PONA - Paraffin	ASTM D5134	wt %	45.653		
- Olefin	ASTM D5134	wt %	0.000		
- Naphthene	ASTM D5134	wt %	39.927		
- Aromatic	ASTM D5134	wt %	13.959		
Ramsbottom Carbon Residue (10% Bottom)	ASTM D524	wt %			0.03
Refractive Index @ 70 °C	ASTM D 1218	ND70C		1.4266	1.4537
Reid Vapour Pressure	ASTM D323	psi	4.2		
Research Octane Number	ASTM D 2699	-	69.0		
Smoke Point	ASTM D 1322	mm	20.5	19.5	
Sulphur Content	ASTM D4294	wt %	0.0004	0.0231	0.0422
Total Acid Number	ASTM D664	mgKOH/g		0.01	0.09
Total Nitrogen	ASTM D3228	wt %			0.0075
Total Nitrogen	ASTM D4629	ppm (wt)	<1	2.4	75.4
Distillation (Measured Value)	ASTM D 86				
- T _i Initial Boiling Point		°C	46.7	152.1	249.8
- T ₅ 5% Volume		°C	62.1	164.1	265.3
- T ₁₀ 10% Volume		°C	74.0	169.1	267.6
- T ₂₀ 20% Volume		°C	84.0	174.8	271.0
- T ₃₀ 30% Volume		°C	91.4	179.6	275.0
- T ₄₀ 40% Volume		°C	96.5	185.0	279.9
- T ₅₀ 50% Volume		°C	101.0	190.8	285.4
- T ₆₀ 60% Volume		°C	105.6	197.2	291.9
- T ₇₀ 70% Volume		°C	111.0	204.4	300.2
- T ₈₀ 80% Volume		°C	117.5	211.8	310.7
- T ₉₀ 90% Volume		°C	126.7	220.0	323.5
- T ₉₅ 95% Volume		°C	133.9	225.2	332.2
- T _f Final Boiling Point		°C	155.2	230.9	336.3
Evaporated		vol %	99.0	98.9	98.6
Residue		vol %	1.0	1.1	1.4

Remarks :

- 1) SG @60/60°F and the API is calculated using Table Measurement as mentioned in ASTM D1250.
- 2) ## : Cannot perform the test due to the Kinematic Viscosity at 40°C is less than 5.5 cSt.

Table 8 : Heavy Naphtha / Jet Fuel Cuts Analyses

Analytical Tests	Method	Unit	Results		
			360 °C - 400 °C	400 °C - 450 °C	450 °C - 540 °C
Yield on Crude	ASTM D2892	mass %	8.34	10.84	11.91
Yield on Crude	ASTM D2892	vol %	8.18	10.28	10.97
Mid Volume %	ASTM D2892	vol %	69.05	78.28	88.91
Density @ 15°C	ASTM D 4052	g/cm ³	0.8631	0.8921	0.9182
API Gravity @ 60°F	Calculated	-	32.36	27.03	22.52
Specific Gravity @ 60/60°F	Calculated	-	0.8636	0.8926	0.9187
Density @ 15.6 °C (60°F)	ASTM D 4052	g/cm ³	0.8627	0.8917	0.9178
Aniline Point	ASTM D 611	°C	93.40	101.50	103.30
Ash Content	ASTM D482	wt %	<0.001	0.001	0.002
Basic Nitrogen	UOP - 269	wt %	0.0135	0.0159	0.0221
Asphaltenes Content	IP - 143	wt %	<0.05	<0.05	<0.05
Calculated Cetane Index	ASTM D4737	-	80.1	75.2	61.40
Carbon Content	ASTM D5291	wt %	86.20	86.50	86.40
Hydrogen Content	ASTM D5291	wt %	14.80	14.60	14.20
Cloud Point	ASTM D2500	°C	48	68	#
Color - ASTM	ASTM D1500	-	L2.5	L7.5	D8.0
Conradson Carbon Residue	ASTM D189	wt %	<0.01	<0.01	0.23
Kinematic Viscosity @ 50°C	ASTM D445	cSt	9.127	##	##
Kinematic Viscosity @ 70°C	ASTM D 445	cSt	5.520	12.11	24.21
Kinematic Viscosity @ 100 °C	ASTM D445	cSt	3.115	5.849	10.15
Viscosity Gravity Constant @ 100 °C	ASTM D2501	-	0.8204	0.8366	0.8542
Metal - Copper (Cu)	AAS	ppm wt	<1	<1	<1
- Iron (Fe)	AAS	ppm wt	1.2	<1	<1
- Nickel (Ni)	AAS	ppm wt	<1	<1	<1
- Sodium (Na)	AAS	ppm wt	<1	40.1	44.6
- Vanadium (V)	AAS	ppm wt	<1	<1	<1
Pour Point	ASTM D97/5853	°C	+39	+51	+57
Refractive Index @ 70 °C	ASTM D 1218	ND70C	1.4569	1.4678	1.4788
Sulphur Content	ASTM D129	wt %	0.04	0.04	0.06
Total Acid Number	ASTM D664	mgKOH/g	0.18	0.08	0.22
Total Nitrogen	ASTM D3228	wt %	0.0292	0.0345	0.0836
Wax Content	UOP 46	wt %	47.8	41.8	13.5
Distillation (Measured Value)	ASTM D 86				
- T _i Initial Boiling Point		°C	353.0	396.0	405.5
- T ₅ 5% Volume		°C	367.0	411.0	423.5
- T ₁₀ 10% Volume		°C	370.5	413.5	432.5
- T ₂₀ 20% Volume		°C	377.5	422.0	446.0
- T ₃₀ 30% Volume		°C	382.0	428.0	458.0
- T ₄₀ 40% Volume		°C	384.5	432.5	468.5
- T ₅₀ 50% Volume		°C	388.5	440.0	478.0
- T ₆₀ 60% Volume		°C	393.5	444.0	490.0
- T ₇₀ 70% Volume		°C	399.0	450.0	503.0
- T ₈₀ 80% Volume		°C	403.5	458.0	518.5
- T ₉₀ 90% Volume		°C	410.5	467.5	537.5
- T ₉₅ 95% Volume		°C	415.0	473.5	552.0
- T _f Final Boiling Point		°C	428.0	482.0	589.0
Evaporated		vol %	99.5	99.5	99.5
Residue		vol %	0.5	0.5	0.5

Remarks :

- 1) SG @60/60°F and the API is calculated using Table Measurement as mentioned in ASTM D1250.
- 2) # : Cannot perform the test due to the sample is too dark in color.
- 3) ## : Cannot perform the test due to the sample is not flowing at the test temperature.

Table 9 : Kerosene / Light Gas Oil Cuts Analyses

Analytical Tests	Method	Unit	Results		
			360 °C - 540 °C	360 °C +	540 °C +
Yield on Crude	ASTM D 2892	mass %	31.09	37.81	6.72
Yield on Crude	ASTM D 2892	vol %	29.43	35.04	5.61
Mid Volume %	ASTM D2892	vol %	79.68	82.48	97.20
Density @ 15°C	ASTM D 4052	g/cm ³	0.8938	0.9127	1.0144
API Gravity @ 60°F	Calculated	-	26.73	23.45	7.91
Specific Gravity @ 60/60°F	Calculated	-	0.8943	0.9132	1.0150
Density @ 15.6 °C (60 °F)	ASTM D 4052	g/cm3	0.8934	0.9123	1.0141
Aniline Point	ASTM D 611	°C	98.60		
Ash Content	ASTM D482	wt %	0.002	0.055	1.282
Basic Nitrogen	UOP - 269	wt %	0.0231	0.0433	0.1635
Asphaltenes Content	IP - 143	wt %	<0.05	0.44	3.37
Calculated Cetane Index	ASTM D4737	-	62.2		
Carbon Content	ASTM D5291	wt %	86.30	86.50	86.80
Hydrogen Content	ASTM D5291	wt %	14.50	14.10	12.10
Cloud Point	ASTM D2500	°C	#		
Color - ASTM	ASTM D1500	-	D8.0		
Conradson Carbon Residue	ASTM D189	wt %	0.08	2.88	16.97
Gross Heating Value (GCV)	ASTM D240	MJ/kg		*	*
Kinematic Viscosity @ 50 °C	ASTM D445	cSt	22.02		
Kinematic Viscosity @ 70 °C	ASTM D 445	cSt	11.62	21.17	##
Kinematic Viscosity @ 100 °C	ASTM D445	cSt	5.670	9.293	##
Viscosity Gravity Constant @ 100 °C	ASTM D2501	-	0.84	0.8	##
Metal - Copper (Cu)	AAS	ppm wt	2.1	1.5	<1
- Iron (Fe)	AAS	ppm wt	10.1	26.4	94.2
- Nickel (Ni)	AAS	ppm wt	<1	9.8	10.9
- Sodium (Na)	AAS	ppm wt	33.9	184.2	261.3
- Vanadium (V)	AAS	ppm wt	<1	<1	<1
Pour Point	ASTM D97/5853	°C	+48	+51	+75
Refractive Index @ 70 °C	ASTM D 1218	ND70C	1.4690		
Sulphur Content	ASTM D129	wt %	0.04	0.08	0.16
Total Acid Number	ASTM D664	mgKOH/g	0.12	0.25	0.83
Total Nitrogen	ASTM D3228	wt %	0.0587	0.1205	0.2979
Wax Content	UOP 46	wt %	39.2	23.4	<5.0
Distillation (Measured Value)	ASTM D 86				
- T Initial Boiling Point		°C	350.0		
- T 5% Volume		°C	369.5		
- T 10% Volume		°C	377.5		
- T 20% Volume		°C	392.0		
- T 30% Volume		°C	406.5		
- T 40% Volume		°C	422.0		
- T 50% Volume		°C	432.5		
- T 60% Volume		°C	444.5		
- T 70% Volume		°C	459.5		
- T 80% Volume		°C	477.5		
- T 90% Volume		°C	507.0		
- T 95% Volume		°C	529.5		
- T Final Boiling Point		°C	575.5		
Evaporated		vol %	99.5		
Residue		vol %	0.5		

Remarks :

- 1) SG @60/60°F and the API is calculated using Table Measurement as mentioned in ASTM D1250.
- 2) ## : cannot perform the test due to the sample is not flowing at the test temperature.
- 3) * : the residues are not combustible using the test unit and due to safety requirement the analysis is not possible to carry out.

Table 10 : Vacuum Gas Oil / Residue Analyses

Analytical Tests	Method	Unit	330°C +	400°C +
Yield on Crude	ASTM D 2892	mass %	43.31	29.47
Yield on Crude	ASTM D 2892	vol %	40.44	26.86
Mid Volume %	ASTM D2892	vol %	79.70	86.57
Density @ 15°C	ASTM D 4052	g/cm ³	0.9059	0.9271
API Gravity @ 60°F	Calculated	-	24.61	21.04
Specific Gravity @ 60/60°F	Calculated	-	0.9064	0.9276
Density @ 15.6 °C (60°F)	ASTM D 4052	g/cm3	0.9055	0.9267

Remarks :

1) SG @60/60°F and the API is calculated using Table Measurement as mentioned in ASTM D1250.

Figure 3 : Comparison of TBP and Simulated Distillation Curves

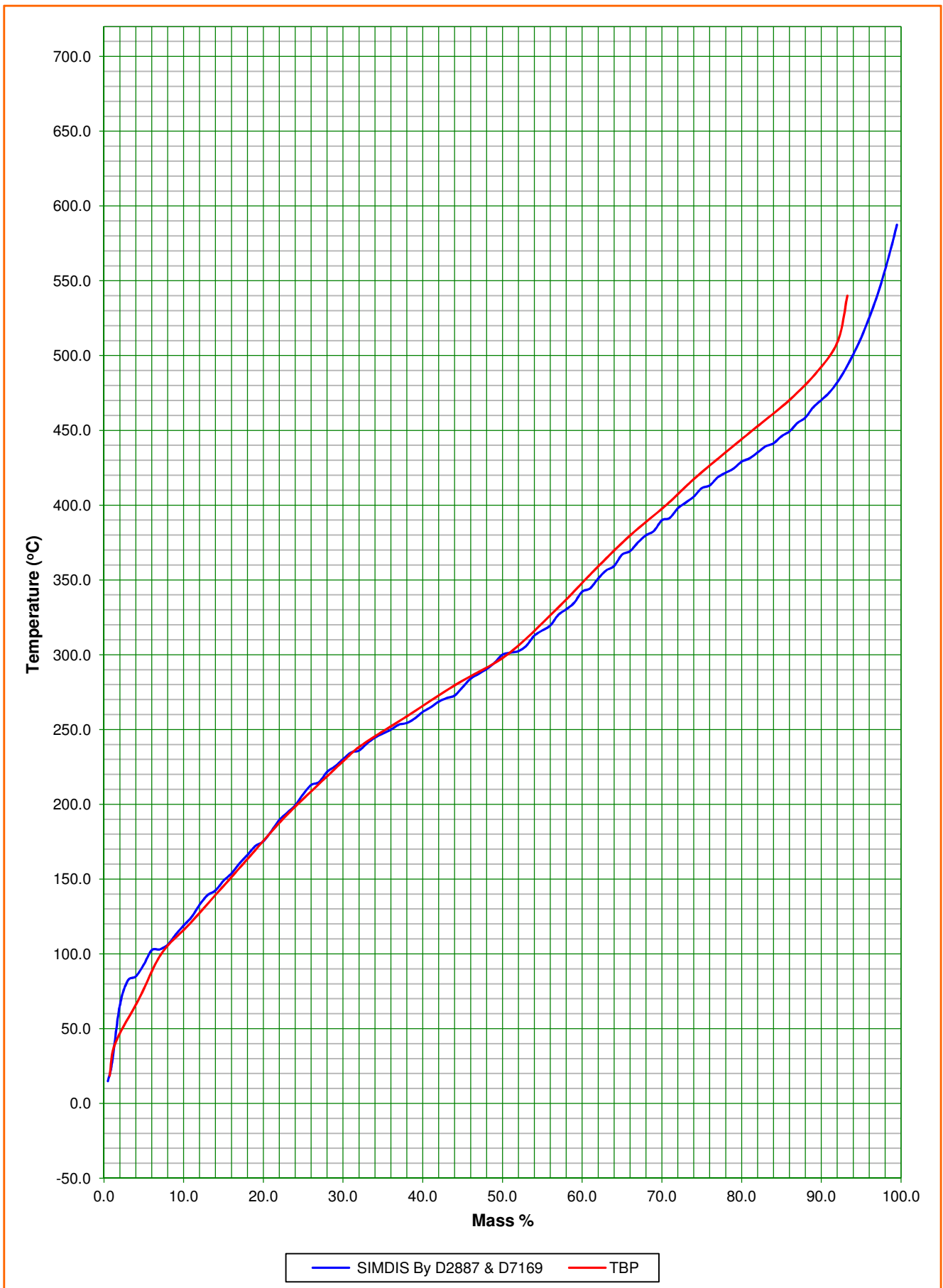


Figure 4 : TBP Distillation Curves (Mass % and Volume %)

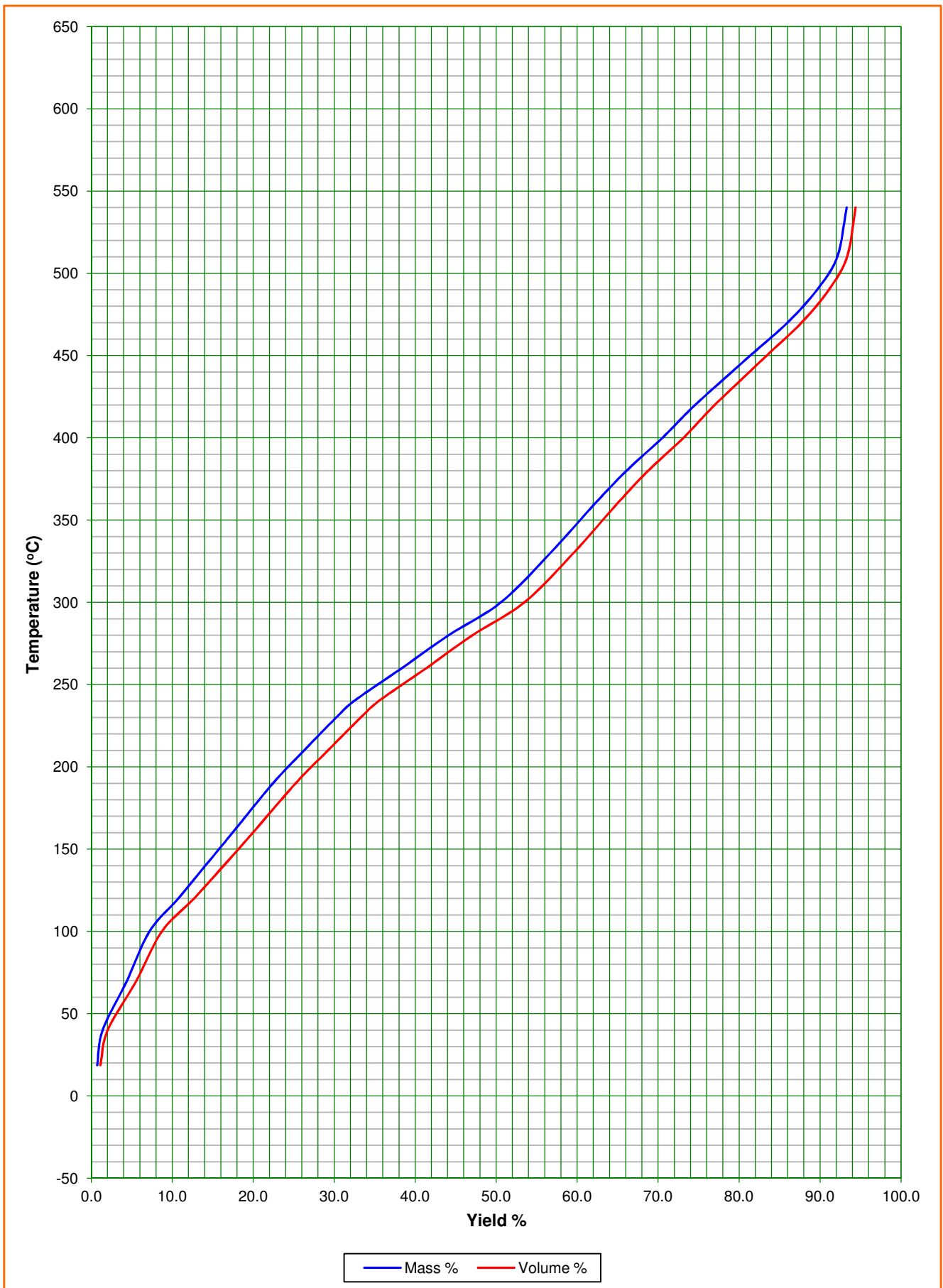


Figure 5 : API Gravity Versus Mid Volume % of Product Cuts

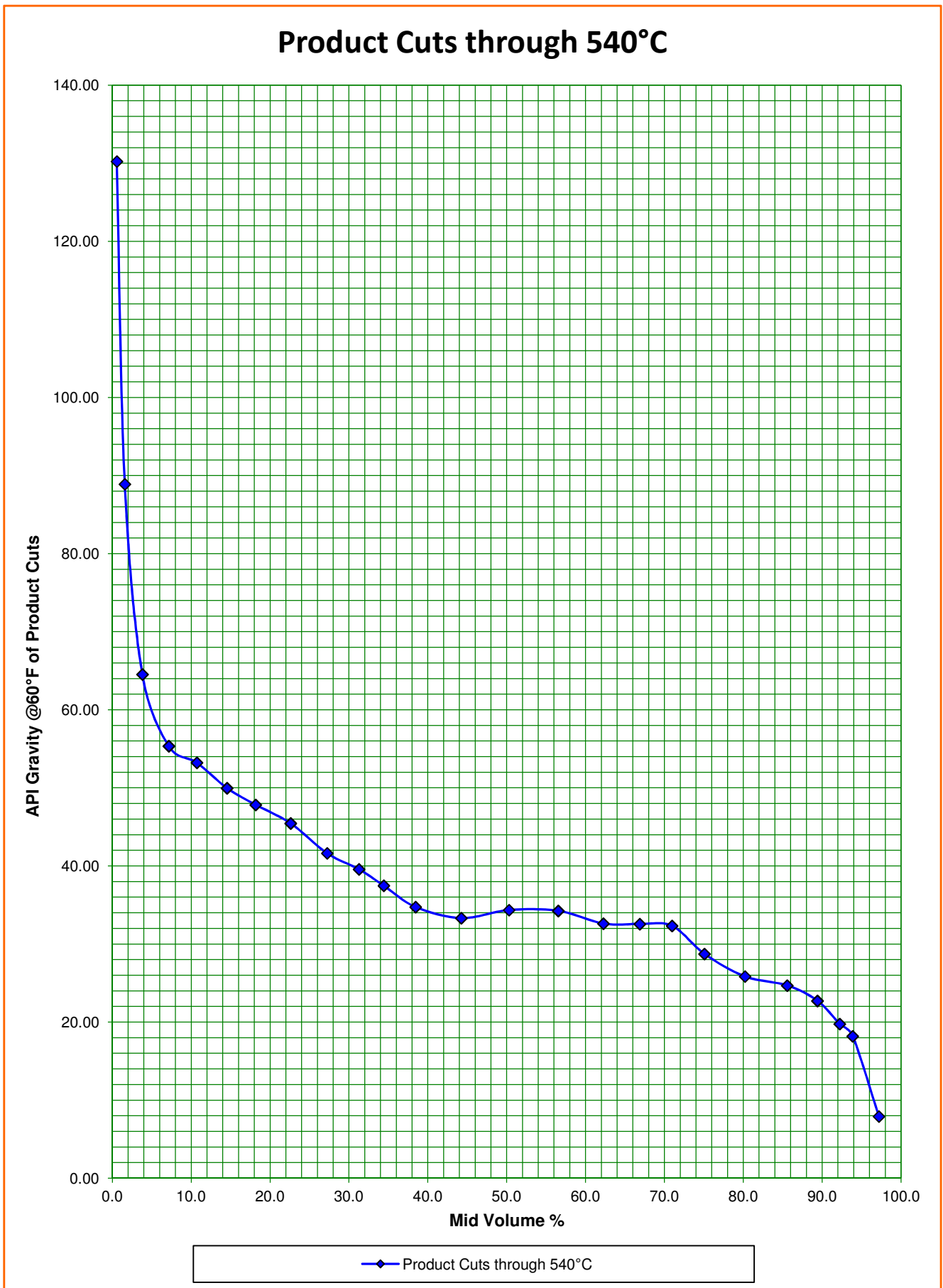


Figure 6 : Total Nitrogen and Total Sulphur Versus Mid Volume % of Product Cuts

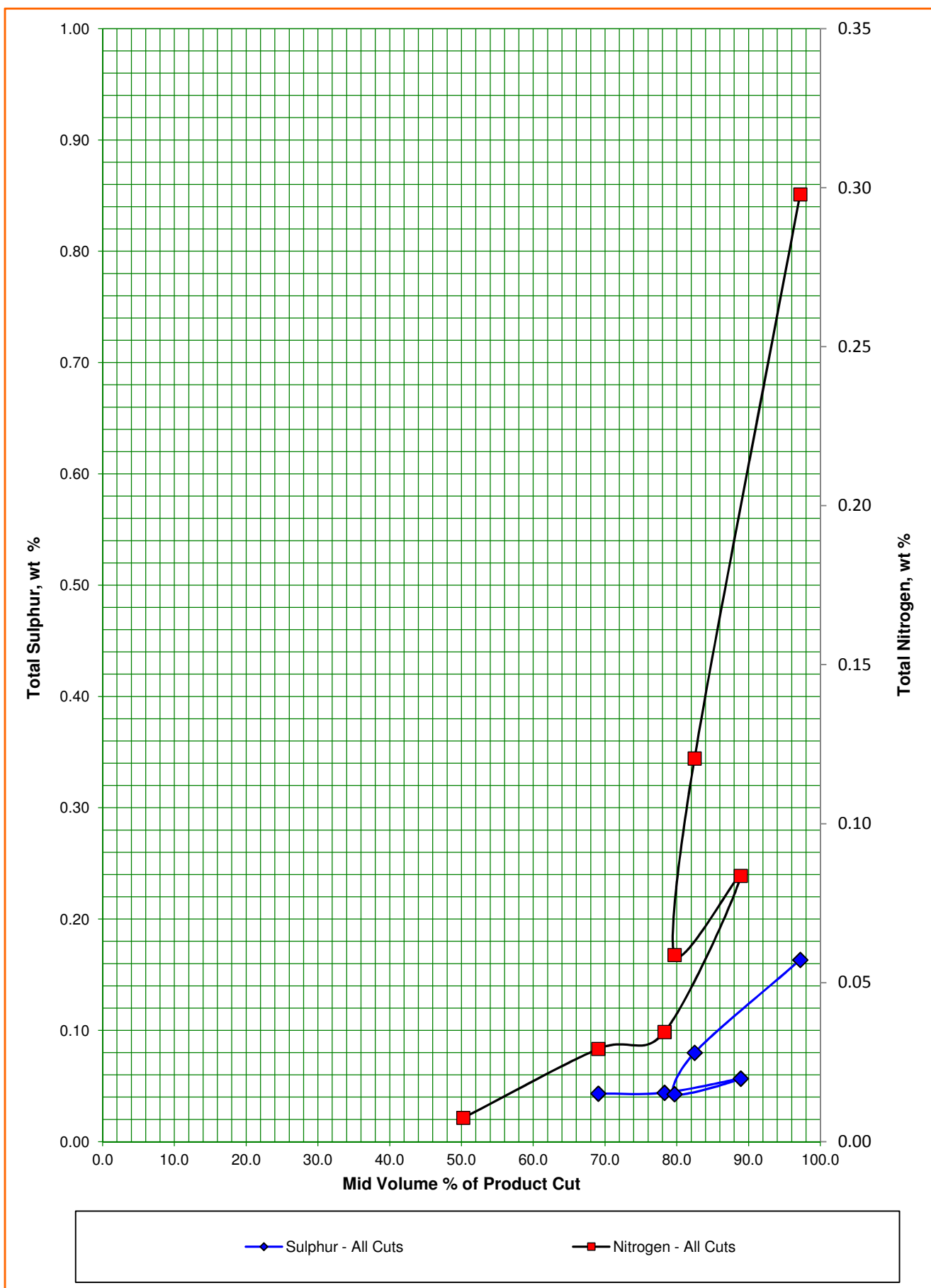
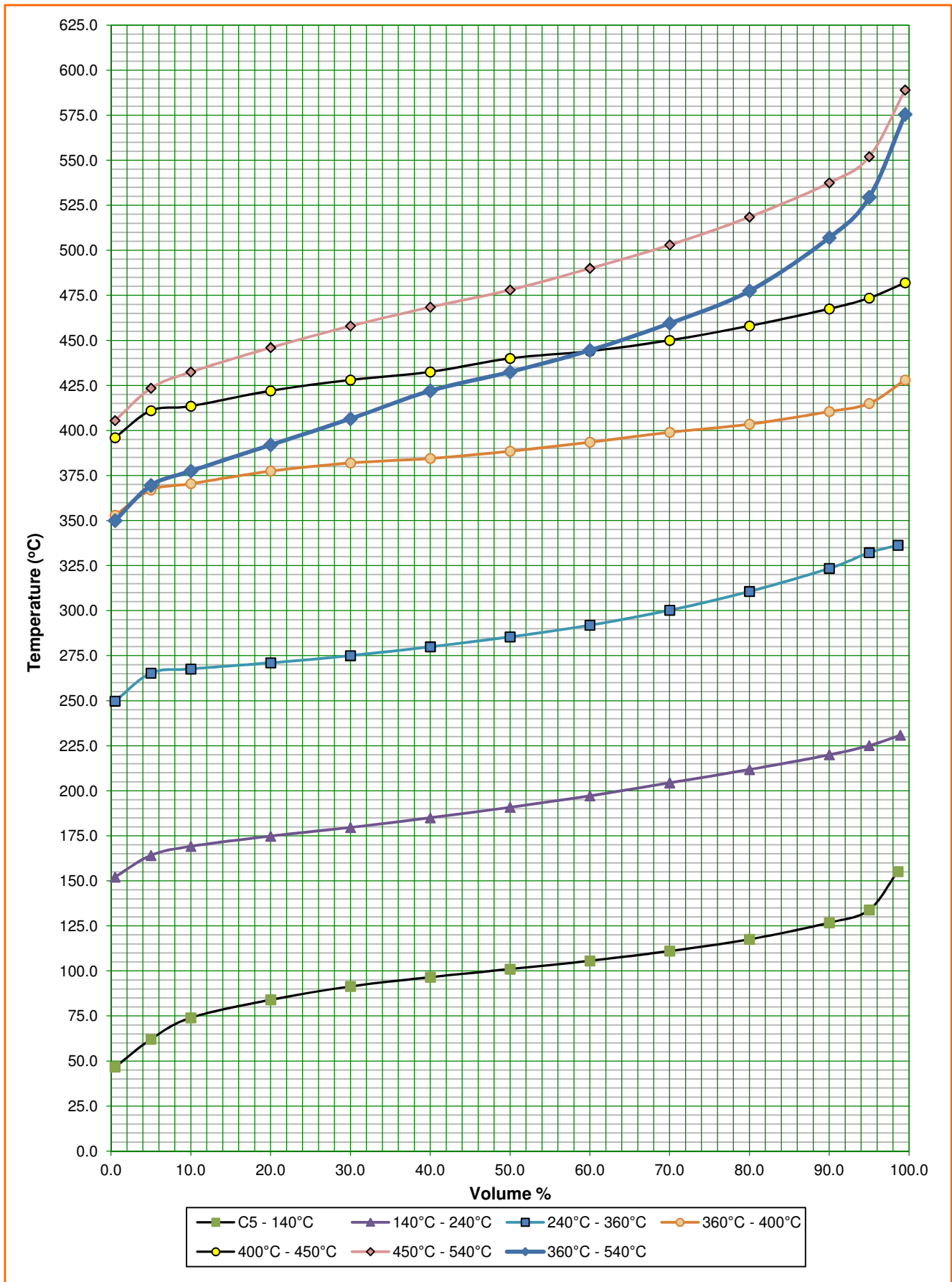


Figure 7 : Distillation Curves for Various Product Cuts by ASTM D 86 and SIMDIS.



Appendix 1 : Test Matrix

No	Description	Method	Units	W h o l e C r u d e	L P G	C 5	1	2	3	4	4	3	3	3	4	5
							4	4	6	0	4	3	6	0	0	0
						-	C	C	C	C	C	C	C	C	C	C
						1	-	-	-	-	-	+	+	+	+	
						4	2	3	4	4	5	5				
						0	4	6	0	5	4	4				
						C	C	C	C	C	C	C				
1	Yield on Crude	ASTM D2892/5236	wt %													
2	Yield on Crude	ASTM D2892/5236	vol %													
3	Density @ 15 °C (59°F)	ASTM D5002	g/cm3													
4	Density @ 15.6 °C (60°F)	ASTM D5002	g/cm3													
5	API Gravity @60°F	ASTM D5002/D4052	degree													
6	Specific Gravity @60°F	ASTM D5002/D4052	degree													
7	Composition - Whole Crude	GC	wt %													
8	Composition (LPG)	GC														
9	Aniline Point	ASTM D 611	°C													
10	Ash Content	ASTM D482	wt %													
11	Antiknock Index (AKI)	ASTM D4814	-													
12	Basic Nitrogen	UOP - 269	wt %													
13	Asphaltenes Stability	ASTM D7112	-													
14	Asphaltenes Content	IP - 143	wt %													
15	Calculated Cetane Index	ASTM D4737	-													
16	Carbon, Hydrogen Content	ASTM D5291	-													
17	Carbon Residue		% m/m													
18	Cloud Point	ASTM D2500	°C													
19	Colour Saybolt	ASTM D 156	-													
20	Color - ASTM	ASTM D1500	-													
21	Cold Finger Plugging Point	IP - 309	°C													
22	Conradson Carbon Residue	ASTM D189	wt %													
23	Copper Corrosion @ 100°C, 2 hrs	ASTM D130														
24	Copper Corrosion @ 50°C, 3 hrs	ASTM D130														
25	Cetane Number	ASTM D613	-													
26	Distillation	ASTM D 86	°C													
27	FIA - Hydrocarbon Type	ASTM D 1319	vol %													
28	Freezing Point	ASTM D 2386	°C													
29	Flash Point (Abel)	IP 170	°C													
30	Flash Point (PMCC)	ASTM D 93	°C													
31	Gross Heating Value (GCV)	ASTM D240	MJ/kg													
32	Hydrogen Sulphide Content	UOP - 163	ppm wt													
33	Kinematic Viscosity @ - 20°C	ASTM D 445	cSt													
34	Kinematic Viscosity @ 20°C	ASTM D 445	cSt													
35	Kinematic Viscosity @ 40°C	ASTM D445	cSt													
36	Kinematic Viscosity @ 50°C	ASTM D445	cSt													
37	Kinematic Viscosity @ 70°C	ASTM D 445	cSt													
38	Kinematic Viscosity @ 100°C	ASTM D445	cSt													
39	Viscosity Gravity Constant @ 100°C	ASTM D2501	-													
40	Viscosity Gravity Constant @ 40°C	ASTM D2501	-													
41	KUOP - Factor	UOP - 375	-													
42	Mercaptan Sulphur	ASTM D3227	ppm wt													
43	Motor Octane Number	ASTM D2700	-													
44	Mercury	UOP 938	ppb wt													
45	Metal - Copper (Cu)	AAS	ppm wt													
	- Iron (Fe)	AAS	ppm wt													
	- Nickel (Ni)	AAS	ppm wt													
	- Sodium (Na)	AAS	ppm wt													
	- Vanadium (V)	AAS	ppm wt													
46	Molecular Weight	Cryoscope	g/mole													
47	Naphthalene Content	ASTM D 1840	vol %													
48	Pour Point	ASTM D97/5853	°C													
49	PONA	ASTM D5134	wt %													
50	Ramsbottom Carbon Residue (10% Bottom)	ASTM D524	wt %													
51	Refractive Index @ 70°C	ASTM D 1218	ND70C													
52	Reid Vapour Pressure	ASTM D323	psi													
53	Research Octane Number	ASTM D 2699	-													
54	SARA	ASTM D2007	wt %													
55	Smoke Point	ASTM D 1322	nm													
56	Sediment by Extraction	ASTM D473	wt %													
57	Sulphur Content	ASTM D129	wt %													
58	Sulphur Content	ASTM D4294	wt %													
59	Total Acid Number	ASTM D664	mgKOH/g													
60	Total Nitrogen	ASTM D3228	wt %													
61	Total Nitrogen	ASTM D4629	ppm (wt)													
62	Water Content	ASTM D95	vol %													
63	WAT	DSC	°C													
64	WDT	DSC	°C													
65	Wax Content	UOP 46	wt %													

Appendix 2 : Summary of Test Methods

Analytical Test	Method Used
Aniline Point	ASTM D611- 12
API Gravity @ 60°F	ASTM D5002 - 13 / D4052 - 11
Ash Content	ASTM D482 - 13
Asphaltene Content	IP 143 - 04
Arsenic Content	SGS In-House No. LAB/INH/020 (As by Hydride Generation)
Boiling Point Distribution of crude oils by High Temperature Gas Chromatography	ASTM D7169 - 11
Calculated Cetane Index	ASTM D976 - 11
Carbon Residue - Micro	ASTM D4530 - 11
Cloud Point	ASTM D2500 - 11
Color - ASTM	ASTM D1500 - 12
Color - Saybolt	ASTM D156 - 15
Density at 15 °C	ASTM D5002 - 13 / D4052 - 11
Density of Semi Solid Bituminous Materials (Pycnometer Method)	ASTM D70 - 09e1
Details Hydrocarbon Analysis	ASTM D6730 - 01(Reapproved 2011)
Distillation - Atmospheric	ASTM D86 - 12
Distillation - Vacuum	ASTM D1160 - 13
Flash Point - Abel	IP 170 / 99
Flash Point - PMCC	ASTM D93 - 15
Freezing Point	ASTM D2386 - 12
Gross Calorific Value	ASTM D240 - 14
Hydrogen Sulphide	UOP 163 - 87
Hydrocarbon Types by FIA	ASTM D1319 - 14
Kinematic Viscosity	ASTM D445 - 15
Koup Factor	UOP 375 - 86
Mercaptan Sulphur	UOP 163 - 87
Mercury Content	UOP 938 - 00
Metals Content	ICP - OES
Naphthalene Content	ASTM D1840 - 07(Reapproved 2013)
Polycyclic Aromatic	IP 391
Pour Point of Petroleum Products	ASTM D97 - 12
Pour Point of Crude Oils	ASTM D5853 - 11
Refractive Index	ASTM D1218 - 12
Total Vapour Pressure	ASTM D5191 - 13
Research Octane Number	ASTM D2699 - 13b
Salt in Crude	ASTM D3230 - 13
Smoke Point	ASTM D1322 - 12e2
Specific Gravity @ 60° F	ASTM D5002 - 13 / D4052 - 11
Sulphur Content	ASTM D4294 - 10
Total Acid Number	ASTM D664 - 11a
Total Nitrogen	ASTM D5762 - 12 / ASTM D4629
Trace Sulphur	ASTM D5453 - 12
True Boiling Point Distillation - 15 Plates	ASTM D2892 - 15
True Boiling Point Distillation - Vacuum Pot Still	ASTM D5236 - 13
Water and Sediment (BSW)	ASTM D4007 - 11
Water by Crude Oils by Potentiometric Karl Fischer Titration	ASTM D4377 - 11
Wax Content	UOP 46 - 85